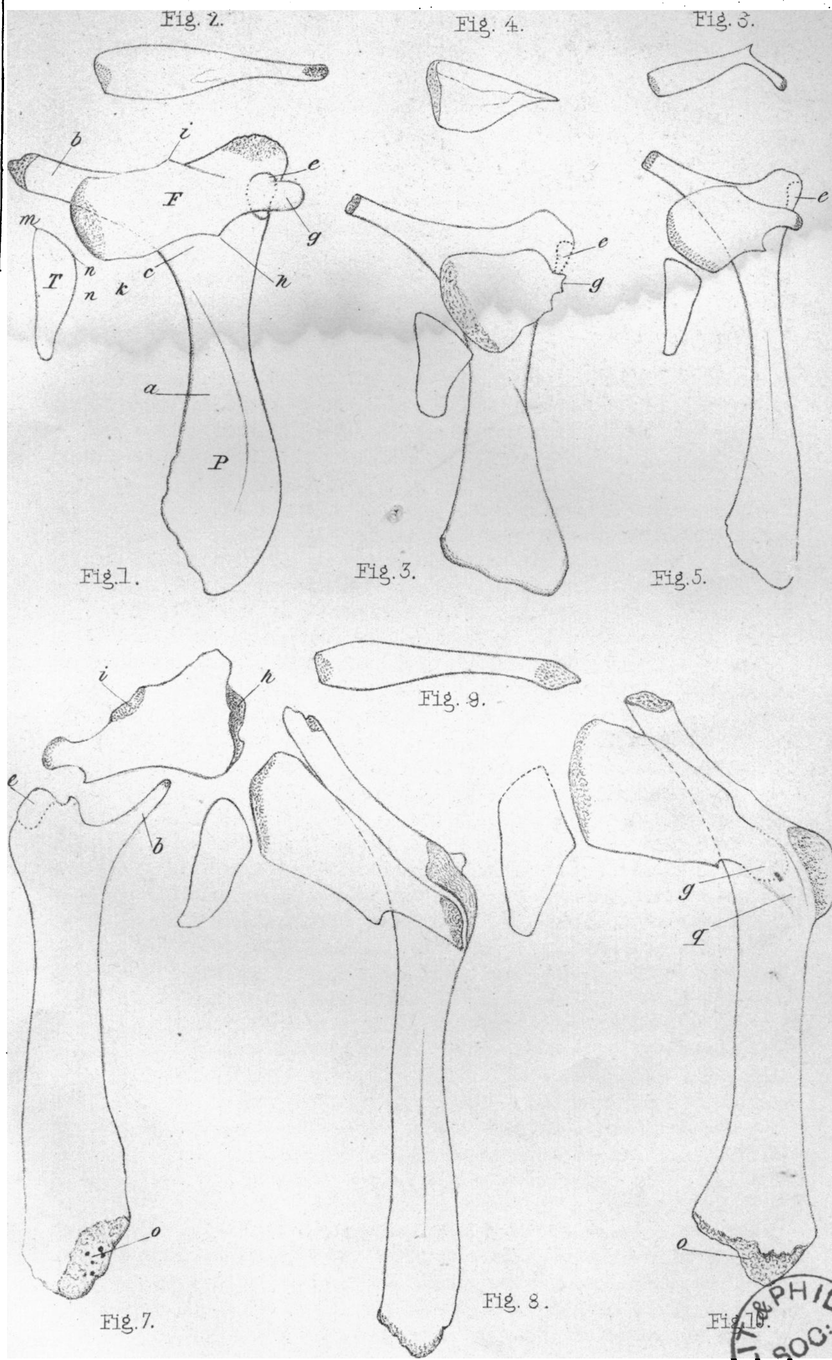

John Struthers, del[t] Gibb & Hay, Lith.

RUDIMENTARY HIND-LIMB OF GREENLAND RIGHT-WHALE. THE BONES.

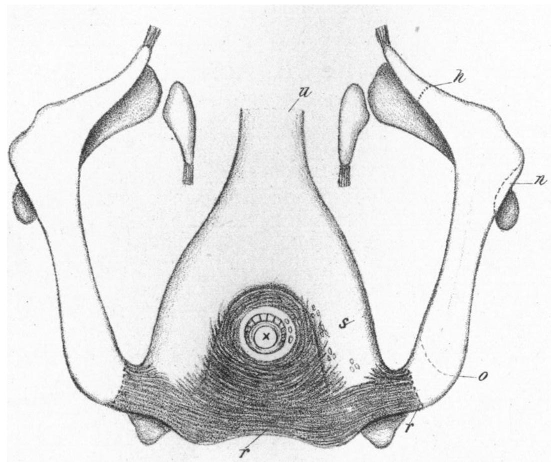

Fig. 12.

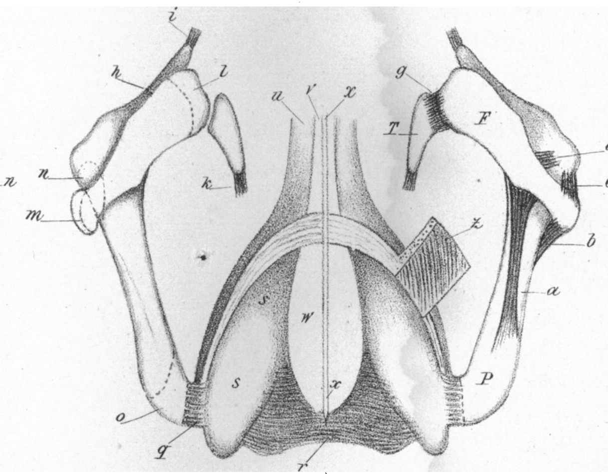

Fig. 11

John Struthers, del[t]

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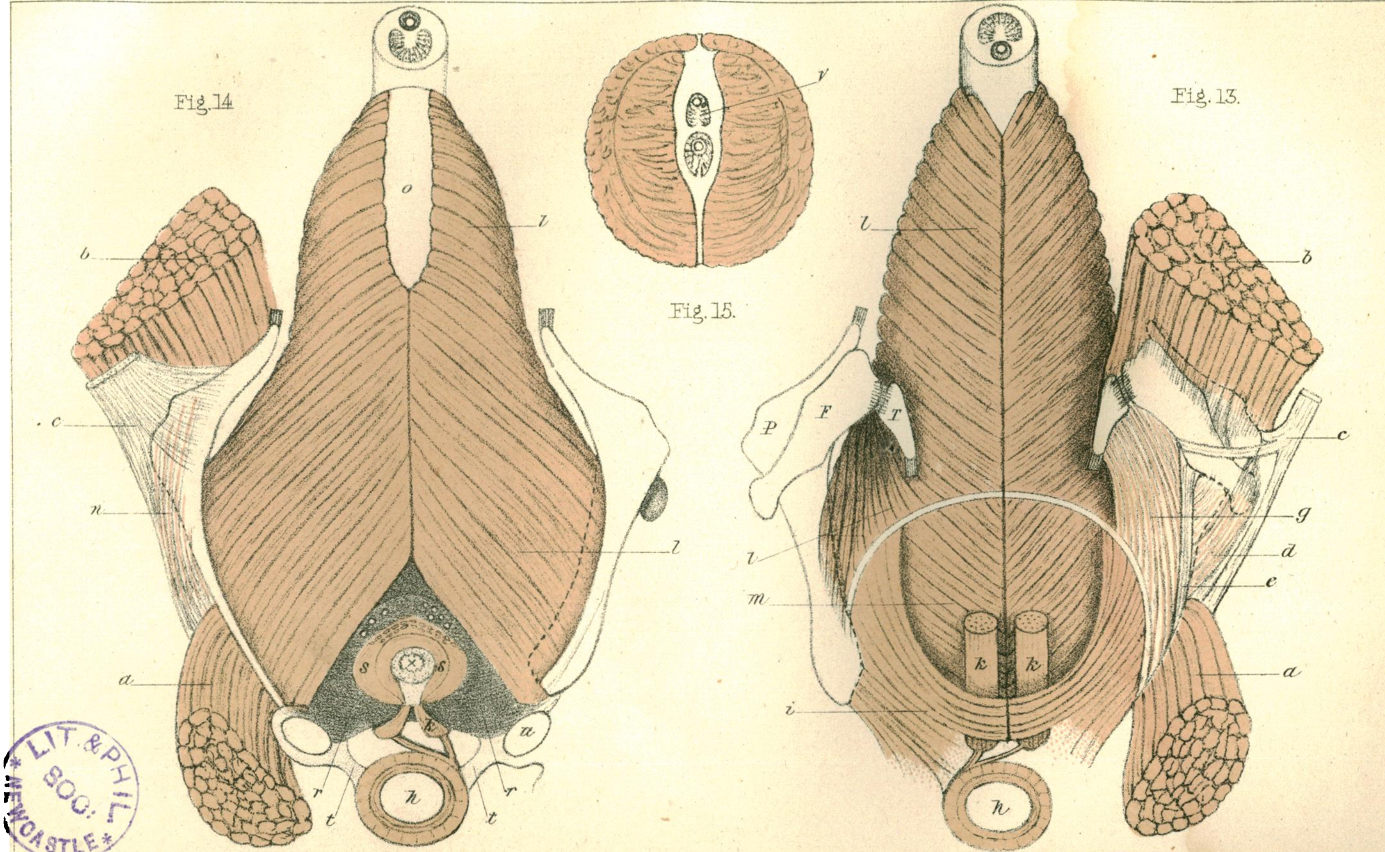
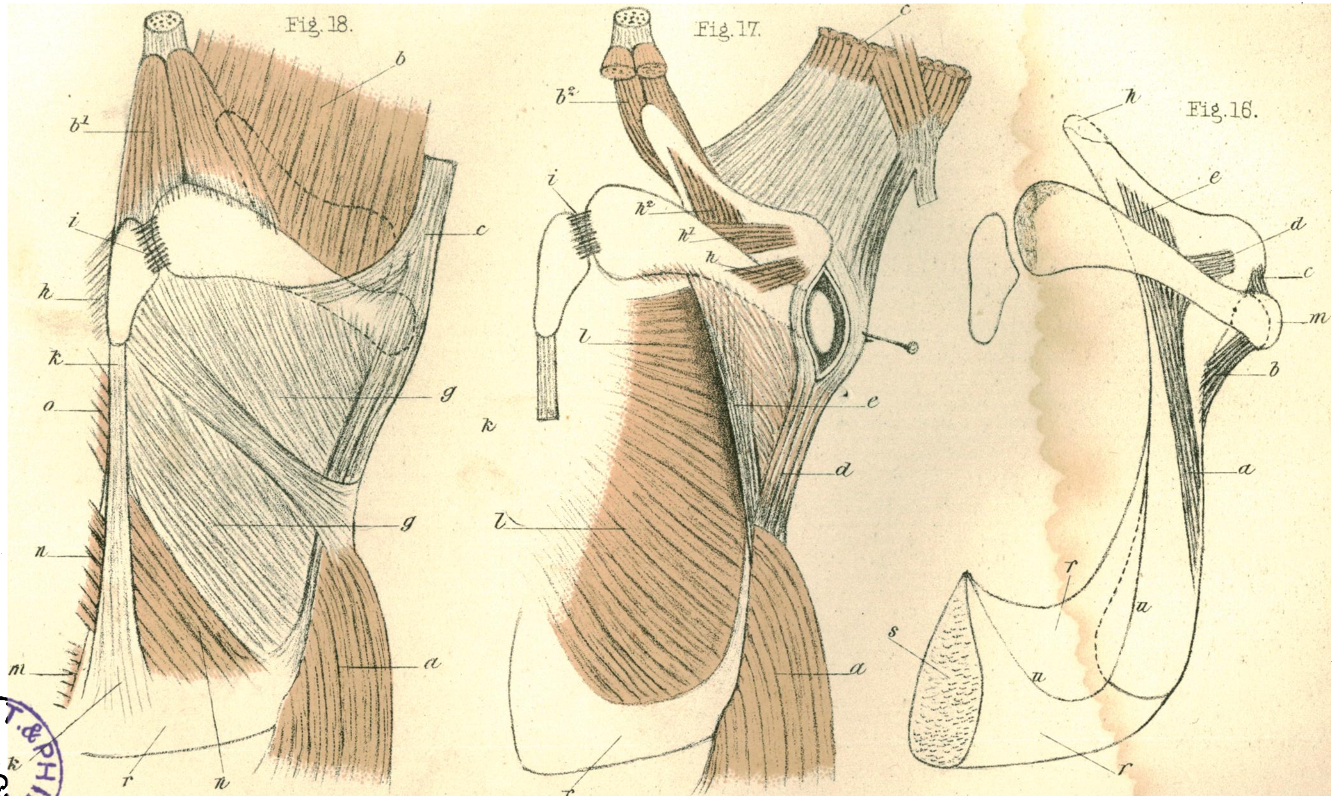
RUDIMENTARY HIND-LIMB OF GREENLAND RIGHT-WHALE. THE LIGAMENTS, &c.



John Struthers, del[t]

Gibb & Hay, Lith[rs] Aberdeen.

RUDIMENTARY HIND-LIMB OF GREENLAND RIGHT-WHALE. THE MUSCLES, MALE.



Gibb & Hay, Lith.rs Aberdeen.

RUDIMENTARY HIND-LIMB OF GREENLAND RIGHT-WHALE. THE MUSCLES, FEMALE.

Journal of Anatomy and Physiology.

ON THE BONES, ARTICULATIONS, AND MUSCLES OF THE RUDIMENTARY HIND-LIMB OF THE GREENLAND RIGHT-WHALE (*Balaena mysticetus*). By JOHN STRUTHERS, M.D., *Professor of Anatomy in the University of Aberdeen.* (PLATES XIV., XV., XVI., XVII).

THE following inquiry was undertaken with the view of seeing what light the dissection of the soft parts might throw on the nature of the bony rudiments which were discovered many years ago by Professor Reinhardt of Copenhagen, attached to the pelvic bone in the Greenland Right-Whale, and which he interpreted as thigh-bone and leg.[1] All of these ten whales (*Balaena*

[1] This interesting discovery was made by Reinhardt in 1843, in a new-born female. Some doubt was entertained by Eschricht whether the one subsidiary bone he had found in *Megaptera*, and the parts previously found by his colleague Reinhardt in *Mysticetus*, were not rather "most analogous to the marsupial bones of the marsupial animals," but the opportunity of examining the parts in a half-grown female *Mysticetus*, taken in 1857, and in a full-grown male in 1860, satisfied these two observers jointly, that the two subsidiary bones are to be interpreted as originally suggested by Reinhardt (*Memoir on the Greenland Right-Whale*, by D. F. Eschricht and J. Reinhardt, 1861; translated from the Danish by Reinhardt, in Ray Society's Publications, London, 1866, edited by Professor Flower). This interpretation is adopted by Professor J. P. Van Beneden of Louvain, from the examination of a pelvis sent to that distinguished cetologist by Reinhardt, "qui a été préparé par les soins du professeur de Copenhague" ("De la composition du Bassin des Cétacés," *Bullet. Acad. Roy. de Belgique*, 2 série, tome xxv., 1868). The entire skeleton of that recently captured adult female *Mysticetus* was at the same time obtained for the Museum of the University of Louvain. So far as I am aware, these are the only specimens of the tibia of the Greenland Whale obtained and preserved in museums previous to those in my possession. The tibiæ are wanting in the skeleton of *Mysticetus* (captured in 1846) now in Brussels, obtained from the Copenhagen Museum; and also in the female skeleton in the Museum of the Royal College of Surgeons of London (1863), also obtained from the Copenhagen Museum. The tibiæ had no doubt been lost in preparing the skeletons.

mysticetus) were taken in Davis Straits. I was greatly indebted to Messrs Patrick H. Macleod, John F. Murison, Donald S. Macdonald, and George Grant, for the care with which, at no small personal risk, they carried out my instructions for procuring these specimens in Davis Straits. The parts were sent to me in Aberdeen, where I dissected them as time permitted between 1873 and 1876. As the dissections proceeded I made life-size drawings of the muscles, &c., and from these the drawings of the soft parts now given are reduced. The descriptions were written from the dissections before me. I gave an abstract of the results of these dissections, and exhibited the specimens, at the meeting of the British Association in Glasgow in September 1876. So far as I am aware, no account had previously been published of the ligaments and muscles connected with these rudiments. The number of specimens which I procured has enabled me also to make observations on the characters and variations of the bones themselves.

Although, from the size of the masses, their fragmentary nature, and the decomposing condition of some of them, the dissections were not easy, the inquiry was a most interesting one. Nothing can be imagined more useless to the animal than rudiments of hind legs entirely buried beneath the skin of a whale, so that one is inclined to suspect that these structures must admit of some other interpretation. Yet, approaching the inquiry with the most sceptical determination, one cannot help being convinced, as the dissection goes on, that these rudiments really are femur and tibia. The synovial capsule representing the knee-joint was too evident to be overlooked. An acetabular cartilage, synovial cavity, and head of femur, together represent the hip-joint. Attached to this femur is an apparatus of constant and strong ligaments, permitting and restraining movements in certain directions; and muscles are present, some passing to the femur from distant parts, some proceeding immediately from the pelvic bone to the femur, by which movements of the thigh-bone are performed; and these ligaments and muscles present abundant instances of exact and interesting adaptation. But the movements of the femur are extremely limited, and in two of these whales the hip-joint was firmly anchylosed, in one of them on one side, in the other on both sides, without trace of disease, showing that these movements may be dispensed with.

The function point of view fails to account for the presence of a femur in addition to processes from the pelvic bone. Altogether, these hind legs in this whale present for contemplation a most interesting instance of those significant parts in an animal—rudimentary structures.

The parts will be considered in the following order:—

In Table I. measurements are given of the pelvic bone from eleven Right-Whales, showing variations with sex, side, individual, and age.

In Table II. measurements are given of the femur and tibia from ten Right-Whales, showing variations.

(A) The Bones.

I. *The Pelvic Bone*—
1. Its nature.
2. Characters and adaptations.
3. Differences with sex.
4. Individual variations.
5. Symmetry.
6. Foramen.
7. Cartilages of the pelvic bone, periosteum.

II. *The Femur*—
8. General characters.
9. Individual variations.
10. Weight, sex, symmetry.
11. Cartilages of the femur, periosteum.

III. *The Tibia*—
12. Condition, form, variations, perichondrium.

(B) The Articulations.

I. *The Knee-Joint*—
13. Synovial cavity, surfaces, ligaments, movements.

II. *The Hip-Joint*—
14. Position and movements of the femur.
15. The ligaments.
16. Synovial cavity.
17. The acetabular cartilage.
18. Variations and adaptations of the hip-joint in the several specimens.

(C) The Muscles.

19. Relation of the genital organs in the male, interpelvic ligament, muscles. Relation in the female.
20. The posterior muscular connections.
21. The anterior muscular connections.
22. Muscles between the pelvic bone and the femur.
23. The muscular and tendinous connections of the tibia.
24. Explanation of the Drawings.

Table I.—Measurements of the Pelvic Bone from

Whale.	Sex.	Length of Whale.	Side observed.	Length.						Breadth.			
				Extreme.		Posterior part.		Anterior part.		Greatest of posterior part.		At angle.	
No.		Feet.		R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
I.	M.	35	R. L.	$8\frac{1}{4}$	$8\frac{1}{4}$	8	8	$3\frac{1}{4}$	$3\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$
II.	F.	58 to 60	R. L.	$14\frac{1}{2}$	$15\frac{1}{8}$	$14\frac{1}{2}$	$14\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{3}{4}$	$5\frac{1}{8}$	$5\frac{1}{8}$
III.	F.	48	R. L.	17	$17\frac{1}{2}$	$15\frac{1}{4}$	$15\frac{3}{4}$	$7\frac{1}{2}$	$7\frac{1}{2}$	$2\frac{3}{8}$	$2\frac{3}{4}$	$3\frac{5}{8}$	$4\frac{1}{4}$
IV.	F.	About 62	R. L.	$15\frac{3}{8}$	$14\frac{1}{2}$	$13\frac{5}{8}$	$13\frac{4}{8}$	$5\frac{1}{2}$	5	2	$2\frac{1}{4}$	$3\frac{1}{8}$	$3\frac{3}{8}$
V.	F.	44 to 45	R. L.	$13\frac{1}{2}$	$13\frac{1}{2}$	$11\frac{3}{4}$	12	$7\frac{1}{2}$	$7\frac{1}{8}$	$3\frac{1}{2}$	4	$4\frac{1}{4}$	$4\frac{3}{8}$
VI.	F.	42	R. L.	$10\frac{5}{8}$	$10\frac{3}{8}$	$9\frac{3}{8}$	$9\frac{1}{4}$	$4\frac{3}{4}$	$4\frac{5}{8}$	$2\frac{1}{4}$	$1\frac{7}{8}$	$3\frac{1}{4}$	$3\frac{1}{8}$
VII.	M.	48	L.	...	20	...	$15\frac{3}{4}$	...	$8\frac{3}{8}$	...	$2\frac{1}{4}$	...	$2\frac{1}{2}$
VIII.	M.	Good size, but not largest size.	R. L.	$18\frac{5}{8}$	$19\frac{1}{8}$	$14\frac{1}{2}$	$14\frac{3}{4}$	$8\frac{1}{8}$	9	$3\frac{1}{2}$	$3\frac{1}{2}$	3	$3\frac{3}{4}$
IX.	M.	Large.	R.	$16\frac{1}{2}$	...	16	...	5	...	3	...	$3\frac{1}{2}$	...
X.	F.	Not very large.	R. L.	$13\frac{1}{2}$	$13\frac{3}{8}$	$12\frac{3}{8}$	$11\frac{7}{8}$	$6\frac{1}{2}$	$6\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{3}{8}$	4	$3\frac{5}{8}$
XI.	F.	Found on shore.	R.	$18\frac{7}{8}$	...	14	...	$9\frac{5}{8}$	...	$3\frac{7}{8}$	...	$3\frac{5}{8}$	...

Explanations of Table I.

1. The "lengths" are exclusive of the cartilages. The thickness of the cartilages which were present is given in the text (section 7).
2. The "posterior part" is measured to the anterior end of the promontory.
3. The "anterior part" is measured from the outer side of the promontory.
4. The "thickness at angle" is taken at the middle of the angular part of the bone.
5. By "angle" is meant the angle formed posteriorly by the meeting of the axis of the posterior part with the axis of the anterior part of the bone.

ELEVEN GREENLAND RIGHT-WHALES (*Balaena mysticetus*).

Thickness. Greatest of posterior part. R.	L.	Thickness. At angle. R.	L.	Depth of the Concavities. Inner border.	Outer border	Anterior border.	Under surface.	Upper surface.	Angle. R.	L.	Weight when cleaned and dried. R.	L.	Figured in the Drawings. No.
$\frac{6}{8}$	$\frac{7}{8}$	$\frac{4}{8}$	...	...	...	...	...	...	120	120	...	...	11, 12, 13, 14, 15
$1\frac{5}{8}$	$1\frac{4}{8}$	$\frac{3}{4}$	1	$3\frac{3}{8}$	1	$\frac{6}{8}$	$1\frac{1}{4}$	$\frac{1}{8}$	90	100	15·363	17·20	1
$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{3}{4}$	$\frac{5}{8}$	$2\frac{3}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$1\frac{3}{16}$	$\frac{11}{16}$	130	130	14·160	14·140	16, 17, 18,
$\frac{6}{8}$	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{2}{8}$	$1\frac{3}{4}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{7}{8}$	$\frac{5}{8}$	135	135	7·369	7·332	5
$\frac{6}{8}$	$\frac{5}{8}$	$\frac{7}{8}$	$\frac{11}{16}$	$2\frac{3}{8}$	$1\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{32}$	115	113	15·369*	10·424	3
$\frac{6}{8}$	$\frac{6}{8}$	$\frac{6}{8}$	$\frac{5}{8}$	$1\frac{1}{2}$	$\frac{6}{8}$	$\frac{3}{16}$	$1\frac{1}{16}$	$\frac{3}{16}$	125	125	6·399	5·254	...
...	$1\frac{3}{4}$	...	$\frac{3}{4}$	$2\frac{5}{8}$	$\frac{6}{8}$	$\frac{1}{8}$	$1\frac{5}{8}$	$\frac{1}{8}$	...	143	...	21·389	8
$2\frac{1}{4}$	$2\frac{3}{4}$	...	...	$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{3}{8}$	145	145	40·90*	42·200*	10
$1\frac{5}{8}$	...	$1\frac{2}{8}$	...	$1\frac{3}{8}$	$\frac{1}{2}$	$1\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	135	...	29·369	...	7
$\frac{7}{8}$	$\frac{13}{16}$	$\frac{5}{8}$	$\frac{9}{16}$	$2\frac{5}{16}$	$\frac{9}{16}$	$\frac{13}{16}$	$\frac{6}{16}$	$\frac{5}{16}$	125	130	8·239	8·85	...
$\frac{7}{8}$	...	$\frac{5}{8}$	...	$2\frac{7}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{4}$	135	...	13·344	...	...

6. The measurements are given in inches and parts of an inch (English).

7. The weights are given in ounces and grains (English). In each column the first figures are ounces, the second figures are grains.

8*. The weight of the pelvic bone in Whale No. V., of the right side, includes that of the anchylosed femur (weight of left femur, 2 ounces 430 grains). The weight of the pelvic bone in Whale No. VIII., of both sides, includes that of the anchylosed femur, for which fully 5 to 6 ounces may be allowed.

TABLE II.—MEASUREMENTS OF THE FEMUR AND TIBIA FROM

WHALE.	FEMUR.													
	Length of Femur.		Breadth.						Thickness.					
			Head.		At middle.		At distal end.		Head.		At middle.		At distal end.	
No.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
I.	$5\frac{3}{8}$	$5\frac{1}{8}$	1	1	$1\frac{1}{8}$	1	$1\frac{3}{4}$	$1\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	1	1
II.	$7\frac{3}{4}$	$7\frac{3}{8}$	$1\frac{1}{4}$	1	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$\frac{7}{16}$	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$
III.	9	$8\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	1	$\frac{7}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$
IV.	4	$4\frac{1}{4}$	$\frac{3}{8}$	$\frac{4}{8}$	$2\frac{1}{8}$	$2\frac{15}{16}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	1	$\frac{7}{8}$	$\frac{15}{16}$	1
V.	5	$3\frac{5}{8}$	...	$\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{7}{8}$	$3\frac{5}{8}$	$3\frac{3}{8}$	...	$\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{7}{8}$	2	2
VI.	$6\frac{1}{4}$	6	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{5}{8}$	$1\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{11}{16}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{8}$
VII.	...	$8\frac{1}{4}$	...	$1\frac{3}{4}$	...	$2\frac{1}{2}$	...	$3\frac{1}{2}$	...	1	...	1	...	$1\frac{3}{8}$
VIII.	7	7	...	...	$2\frac{3}{4}$	$2\frac{3}{4}$	$4\frac{1}{8}$	$4\frac{1}{8}$	...	...	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{6}{8}$
IX.	$6\frac{1}{4}$	...	$1\frac{1}{8}$	...	$2\frac{1}{2}$	...	4	...	$\frac{5}{8}$	...	2	...	$2\frac{1}{4}$	...
X.	$5\frac{3}{8}$	...	$\frac{1}{2}$	...	$2\frac{1}{2}$	...	$2\frac{1}{4}$	...	$\frac{1}{4}$	...	$\frac{7}{8}$	...	$1\frac{2}{8}$	...

EXPLANATIONS OF TABLE II.

1. For the sex, and the length, of each of these whales, see the same ten whales in Table I.

2. The length of the femur is exclusive of the cartilages. The thickness of the cartilages which were present is given in the text (section 11).

TEN GREENLAND RIGHT WHALES (*Balaena mysticetus*).

FEMUR.		TIBIA.												Figured in the Drawings.
Weight when cleaned and dried.		Length of Tibia.		Breadth.				Thickness.				Weight. Moist in spirit.		
				At base.		Half-inch from apex.		At base.		Half-inch from apex.				
R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	No.
...	...	$2\frac{3}{8}$	$2\frac{4}{8}$	1	$\frac{7}{8}$	$\frac{6}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	...	...	11, 12 13, 14
5·10	4·284	$3\frac{3}{8}$	$3\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{4}{8}$	1·180	2·4	1, 2
3·325	3·339	Injured		...	...	...	...	...	...	...	...	...	...	16, 17 18
1·315	2·6	$3\frac{1}{8}$	...	$1\frac{1}{4}$	...	$\frac{6}{8}$	...	1	...	$\frac{5}{8}$	...	1·4	...	5, 6
*	2·430	$3\frac{3}{4}$	$3\frac{1}{8}$	$1\frac{6}{8}$	$1\frac{7}{8}$	$\frac{6}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{6}{8}$	1·351	2·30	3, 4
3·30	2·130	Not obtained						...	...	...	...	...	...	...
...	5·383	...	$4\frac{1}{4}$	...	$1\frac{6}{8}$	...	$\frac{7}{8}$	...	$1\frac{1}{4}$	...	$\frac{4}{8}$	...	2·13	8, 9
*	*	Injured		...	$2\frac{1}{2}$	...	...	...	$1\frac{1}{8}$	...	...	...	...	10
7·70	...	Not obtained						...	...	...	...	...	...	7
2·339	...	Not obtained						...	...	...	...	...	...	...

3. The breadth and thickness of the tibia "at base," were taken on a level with the posterior angle of the base, and therefore about $\frac{3}{4}$ inch from the extreme anterior end.
4. As in Table I. the measurements are in inches, the weights in ounces and grains.
5. The weights of the femur in No. V. right, and in No. VIII., are included in those of the pelvic bones to which they are anchylosed. See Table I.

(A.) THE BONES.

I. The Pelvic Bone.

1. *Its Nature.*—The use of the terms ischial, iliac, and pubic, applied to the different processes of the pelvic bone, diverging from the acetabulum, would be convenient and would simplify the names of the muscles and ligaments, but, as there is no evidence that the pelvic bone is developed from more than one centre of ossification, these terms are apt to mislead. The term innominate for like reason is objectionable. The anterior part no doubt suggests the horizontal ramus of a pubes, especially in some, but if we look at the pelvis of a seal, in which the ilium and femur are greatly reduced, that part of the pubes is seen to be directed backwards like the ischium. If we suppose the anterior of the two slender bones of the dugong, which afterwards anchylose together, to be omitted, we have the Cetacean pelvic bone represented by the ischium alone, sending off two processes, anterior and posterior, at its acetabular part. These are for muscular and ligamentous attachment. The posterior part, besides attaching muscles and ligaments, attaches the crus penis, entitling us to regard the one pelvic bone as an ischium. The pelvic bone will therefore here be spoken of simply as presenting a posterior part, an anterior part, and an angular part, the latter projecting externally as a promontory. The posterior part may be conveniently termed the body, the anterior part the beak.

2. *Characters and Adaptations of the Pelvic Bone.*—Viewed as a whole the bone presents two surfaces, superior and inferior, and three borders, internal, external, and anterior, the two latter separated by the promontory. Longitudinally, each surface presents two curvatures; the under surface, very concave along its anterior half, and convex along its posterior half; the upper surface, the reverse. Each of the three borders is concave, the outer and inner borders becoming more or less convex behind, according to the shape of the posterior end.

(*a.*) *Posterior Part, or Body.*—The hinder end, rough, attaches the great interpelvic ligament, and, together with the inner margin near it, varies greatly with sex. On the superficial surface a prominent ridge is seen, directed forwards and inwards. It attaches the great posterior ligament of the femur. The outer slope of the surface attaches, along its hinder half, the caudal muscular mass, the internal and broader slope, the perineal mass. The deep surface is occupied, along its hinder half, by the same muscles, but the dividing ridge is less marked on this surface. These ridges or elevations, more or less marked, may be traced forwards to the inner border of the bone, at or in front of the angle, and mark off the outer attachment of the great genital muscular mass.

(*b.*) *Angular Part.*—The characters here are the result of adaptations to a hip-joint; an outward extension of the bone supports a hollow for the reception of the femur, and is surmounted by a prominence to which ligaments and muscles are attached. Seen on surface, the promontory is more or less rounded, usually presenting two projections, one external supporting the acetabulum, the other, anterior, for muscular attachment, is more variable. Seen on the edge, the anterior part of the promontory is broad and rough, the outer part thin, being excavated by the acetabulum. If the cartilage is off, the part which it covered may be recognised as an excavated and usually rough area, of an ovoid form. The general acetabular hollow may be very shallow or it may be well cupped.

(*c.*) *The Anterior Part or Beak* tapers gradually from the broad part at the angle to the point. The breadth of this part varies much with that of the angle. About the middle, the breadth is usually about three times as great as the thickness. As at the angular part of the bone, the inferior surface is concave both ways, forming a continuous hollow for the reception of the femur. The more or less transverse position of this part of the pelvic bone adapts it for the attachment of strong muscles which pass backwards to it from the trunk. It also supports the thigh-bone, and attaches ligaments and muscles by which that bone is retained and moved.

2. *Differences of the Pelvic Bone in the Male and Female.*—These differences are more marked than in the human subject. In the female the pelvic bone is shorter, more bent, broader at the angle, and, above all, thinner at and towards the hinder end, than in the male. The shortness is partly owing to the greater bend. Thus in No. II., while the length is $14\frac{1}{2}$ inches, the united lengths of the two portions is 23 inches, the angle being 90°;

while in No. VIII., the length being $18\frac{5}{8}$ inches, the united lengths is $22\frac{5}{8}$ inches, the angle being 145°. But, irrespective of angle, the measurements given in the table show that the bone is shorter in the female. In the 62 feet long female (No. IV.), with an angle of 135°, the length is about 15 inches, while in the 48 feet long male (No VII.) with an angle of 143°, the length is almost 20 inches, the united lengths of the two portions in each being, respectively, 19 and 24 inches. The greater bend of the bone in the female than in the male is probably related to the differences in the external organs or passages. The reason for the exceeding breadth of the bone at the angle in the female is not evident, unless it be the greater thickness in the male, and that the genital muscular mass goes farther forwards on the bone in the female. But the chief difference in the sexes is on the posterior part of the bone, which is so thick and narrow in the male as to be almost rounded in appearance, while in the female it is thin, and may be also broad. The adaptation here is seen by referring to the attachment of the interpelvic ligament to the bone. In the male the thick rounded ligament, supporting the crus penis, is attached to the hinder end of the bone, while in the female the more expanded ligament reaches forwards along the inner margin and upon the bone. It is on the inner side that the increased breadth is gained in the female. In the young female (42 feet long) the expansion towards the hinder end is little marked, nor is it much marked in No. X., while in No. XI., a very fully ossified specimen, the breadth near the hinder end is even greater than at the angle. This thinness of the hinder end is seen in all the female specimens before me, in marked contrast with the thick abrupt ending of the bone in the male.

By referring to the column of weights in Table I., it will be seen that the pelvic bone is much heavier in all the adult males than in any of the females. While among the adult females it varies from about 17 ounces to less than half that weight, in the three adult males it varies from 21 ounces up to 29, and in No. VIII. is probably about 35 ounces.

4. *Individual Variations of the Pelvic Bone.*—While presenting the above characters by which these bones may be recognised and their sex distinguished, they yet present considerable individual variations. Reference may here be made to

the measurements given in Table I. Among the females, the *bend* varies from an angle of 135° to 90°. In the two adult males, Nos. VII. and VIII., the angle is large (143° and 145°), but in the young male (35 feet long) it is only 120°. These specimens give us no ground to suppose that the angle changes with growth or age, although the ends grow at the cartilages. Nos. II. and V. (figs. 1 and 3) have the appearance of being fully adult or old, and they are very much bent (angles 90° and 115°); Nos. IV. (fig. 5) and XI., equally adult or old, have angles of 135°; while No. VI., imperfectly ossified, and No. III. (fig. 16) more fully ossified, have angles, respectively, of 125° and 130°.

The variation in *robustness* is great (as the column of weights indicates), putting aside Nos. I. and VI. as immature. No. VIII. is much more robust than No. VII., especially at the hinder end, where it enlarges onwards to an abrupt rough end, over 3 inches by 2½ inches, facing backwards and inwards, when the interpelvic ligament is attached; while No. VII., though quite as thick at about 4 inches from the end, diminishes conically to a blunt end, not a third the size of the end of No. VIII. The third adult male, No. IX., is here intermediate in form between these two; broader than No. VIII., but not so thick, and terminating in a thick and rough but not expanded end. Among the seven female specimens the differences are still greater. Those of No. IV., the longest of these whales, are very slender, more so than in the 42 feet long individual. There is great variation also in the extent, form, and position of the expansion towards the hinder end. This expansion is much less marked in Nos. III., VI., and X. than in Nos. II., V., and XI.; in No. II. it is greatest at 4 inches from the end, giving an oval, or pointed, end; in No. V. it is greatest behind, giving a somewhat square-shaped end, most pointed externally; in No. XI. the form is intermediate between the two last.

There are likewise well-marked variations in the degree of the *curvatures*. The curvature of the inner border is increased when the bone is broad behind, or when, as in No. X., the hinder part of the body is curved inwards. There is variation in the abruptness with which the promontory stands out, influencing the curvatures of the outer and anterior borders, but variation in the abruptness of the promontory is seen more where it joins the anterior part than where it supports the acetabulum. Nos. III. and IV. (figs. 16 and 5) illustrate this well; on the other hand No. XI. shows the greatest projection at the acetabulum, which in it is large and deep. The curvatures of the surface are, in the adult males, variously marked; least in No. VIII., in which the concavities are mainly owing to the enlargement at the hinder end. Among the females they are strongly marked in Nos. III. and IV., well marked in No. VI., and very slight on the body in Nos. II. and V., in which the expansion posteriorly is great. But in all these specimens, male and female, there is the well-marked concavity of the under surface at and in front of the angle, corresponding to the position of the thigh-bone.

The shortness of the beak in No. VI. is due to immaturity, and in No. X. also the ossification of this end is incomplete; but in No. IX., in which the ossification is complete, the beak presents a remarkable variation (fig. 7). Although the measurement in the table, taken from the outer side of the promontory, gives 5 inches, the length of the projection, from where it leaves the inner side of the bone, is only 3 inches (on the anterior border only $2\frac{1}{2}$), and, instead of being flattened like the others, it is a prism, the anterior and posterior surfaces broader than the surface next the femur. Variations of the acetabulum will be noticed with the hip-joint.

5. *Symmetry of the Pelvic Bones.*—Considering that, although arranged so as to present the appearance of a pelvic girdle, the girdle is without a symphysis and has no function of resistance to perform, the symmetry of these bones is remarkable enough. The a-symmetries noted in the table are slight; mainly little differences in the extent to which ossification has extended at either end. Nos. II., VI. and VIII., however, show considerable difference in weight between the right and left pelvic bone.

6. *Foramen.*—A small foramen is present in most of these specimens, near the inner border, in front of the angle. It is oval, scarcely as large as a crow-quill, and directed, generally, from the under to the upper surface, outwards and backwards. It is absent in both pelvic bones of Nos. II. and VI.; in No. VII., and in the right pelvic bone of Nos. IV. and V., and in

the left of No. X., although well-marked on the other bone in these three. In Nos. V. and IX. its direction is different; from the under to the upper surface, its direction in No. IX. is forwards and inwards, in No. V. forwards and outwards.[1]

7. *The Cartilages of the Pelvic Bone.*—In No. I., the young male, the cartilage of the hinder end is 1 inch in length, continuing the full thickness of the bone backwards and a little inwards, and then attaching the interpelvic ligament. The cartilage of the anterior end is 2 inches in length, tapering to a blunt point, to which a fibrous tuft is attached. In No. V., the anterior cartilage is about $\frac{1}{2}$ inch long, to which a fibrous tuft still remains attached. At the hinder end, which is broad and thin, the cartilage is 1 inch in length externally, $\frac{1}{2}$ inch internally, with a narrow strip along the end between the two corners. When the cartilages are off, the hinder end of the bone presents corresponding appearances; the bevelled corners $\frac{1}{4}$ inch thick with irregular surface, the intervening edge about $\frac{1}{8}$ inch thick and more finished looking. From these appearances of the bone, as well as from the length of this whale (44 to 45 feet), it may be inferred that it was not quite adult, although the right femur is anchylosed to the pelvis. In No. VI., the young female, both the cartilages are lost, exposing the irregular surfaces which have supported them. A cartilage was present on the anterior end of No. III. (about $\frac{1}{4}$ inch long), of No. IV. ($\frac{1}{2}$ inch), of No. VII. ($\frac{1}{6}$ inch) and of No. VIII (a thin layer); intervening between the fibrous tuft and the bone. Ossification having gone farthest on the inner, or posterior, border, the anterior end is very oblique in all the specimens,

[1] *Comparison with the Pelvic Bone in the Great Fin-Whale.*—Comparing these adult male specimens with that of the adult male Fin-Whale (*Balænoptera musculus*) which I figured in 1871 (*Journal of Anatomy and Physiology*) the differences are striking. In that Great Finner the posterior division is shorter by 3 inches (9 and 12) than the anterior, and attaches the crus penis along its posterior $\frac{3}{4}$; and the anterior half of the anterior division is flattened in the opposite direction. In *Mysticetus*, the posterior division averages about twice the length of the anterior. In the Finner the bone is less bent, and the promontory stands out farther and more abruptly, giving a breadth of 5 inches to the bone at this part. There is no acetabulum, or impression of the pelvic bone by the short ovoid rudimentary femur, which lay loosely in the hollow of the border of the bone, $1\frac{1}{2}$ inch in front of the promontory, to the hinder part of the under surface of which was attached the strong triangular ligament, 2 to 3 inches in length, which tied the femur to the pelvis.

except in Nos. IV. and V., in which the obliquity is moderate, in No. II. in which it is slight, and in No. IX. in which the stunted beak tapers to a blunt point. In No. XI., a more contracted and rough portion, $\frac{3}{4}$ inch in length, and about half the thickness of the bone from which it projects, has been concealed by the cartilage.

Any cartilage which may have existed at the *hinder* end of the other specimens (Nos. II., III., IV., VI., VII., VIII., IX., and X.) had been detached with the remains of the ligament. The thin flattened ending in Nos. III., IV., and VI., present the irregular surface of parts which have supported cartilage. No. II. comes to a sharp edge with a finished look, while at the anterior end the surface has evidently supported a cartilage. No. XI. has the same finished look behind. The abrupt ends in the three adult males are coarsely irregular.

It would seem from these facts that the cartilage of the posterior end is shorter in the young than that of the anterior end, and still more so in the adult, but these observations do not determine whether cartilage remains permanently at the hinder end. The cartilage of the acetabulum will be examined with the hip-joint.

The *Periosteum* of the pelvic bone is about $\frac{1}{12}$ inch thick on the surfaces. On the margins, along the three concavities, there is a fibrous wall, $\frac{1}{2}$ inch deep, prismatic in section, filling up the deepest part of the concavities and giving increased breadth.

II. The First Appendicular Bone (The Femur.)

8. *General Characters.* — Among these ten Greenland whales the thigh-bone presents great variation in form, but certain general characters may be recognised. All are sufficiently flattened to present, along the whole bone, two surfaces, separated by an anterior and a posterior border. There is evidently a head, followed by a more or less elongated neck. The neck is defined distally by two tubercles, one on each border, the posterior nearer the head than the anterior; and, beyond this, there is a more or less square-shaped and onwardly enlarging body, the end of which presents a flattened ovoid articular surface, from which, as from the head, a cartilage has been detached in the macerated bone. The right femur may be

distinguished from the left by observing that the deep surface is longitudinally convex, and that the axis of the bone is bent with the concavity backwards.

The *Head* is much flattened in all, an ovoid at the best, and in some reduced to a mere rounded border. It is generally placed obliquely to the axis of the bone, extending farther upon the anterior than on the posterior border of the neck. It presents an irregular surface where the cartilage lay. The *Neck*, a little more contracted than the head, expands gradually onwards to the tubercles. The *posterior tubercle* attaches the great posterior ligament of the femur. It may be regarded as the *great trochanter*. If the ordinary mammalian femur, much shortened, be flexed, adducted, and rotated outwards, it will be brought into the position of the femur in *Mysticetus*. More exactly, if the pelvis and femur of a seal be taken in the hands and so manipulated, the correspondence becomes evident, and it is seen that this tubercle is the trochanter major. It is situated generally at about the junction of the proximal and middle thirds of the bone, but may be somewhat to either side of that point. It occurs as a triangular elevation of the posterior border, varying in abruptness and degree of elevation. The *anterior tubercle* is situated on the anterior border about the middle of the bone, and is rather the angle where the sloping neck joins the more horizontal body than a special process.

The *Body* includes from half to two-thirds of the length of the bone, is the thickest as well as the broadest part, and increases distally, especially in breadth, so as to give a somewhat triangular instead of a quadrangular appearance to the bone. The *distal end* is seen, when the cartilage is removed, to be ovoid, or elongated in the more flattened specimens; a little convex longitudinally, with its most projecting part in front of the middle; to face obliquely downwards, from the ossification having extended further on the deep surface, it may be for fully $\frac{1}{2}$ an inch, than on the superficial surface; and to present the usual irregular appearance of parts which have supported cartilage.

Viewing the surfaces and borders of the femur as a whole, the *deep surface* is longitudinally convex, except near the head, this convexity of the femur corresponding to the concavity of the pelvic bone at and in front of the angle. The *superficial surface* is, longitudinally, concave along the outer half, convex along the body, this convexity being gained by the increased thickness of the bone. The borders are thin along the neck, thick along body.

9. *Individual Variations of the Femur.*—Reference to the table (Table II.) will show that the adult femur varies in length from (without its cartilages) under 4 inches to 9 inches; in breadth, at the distal end, from $2\frac{1}{2}$ to 4 inches; and in thickness, at the same part, from 1 inch to $2\frac{1}{4}$ inches. Among these specimens the following variations of general form may be distinguished: (1) elongated and body square-shaped (Nos. I., II., and VII); (2) elongated and gradually enlarging (Nos. III. and VI.); (3) elongated and body triangular and thick (Nos. VIII. and IX.); (4) short and body thick (No. V.); (5) short and body flattened (Nos. IV. and X). The somewhat square-shaped body, but broader distally than towards the neck, may be regarded as the typical form of body. The neck shows considerable variety in regard to constriction, length, and bend; and the head no less so in regard to size.

Some of the variations presented by the specimens may be here noted. Nos. I. and II. (figs. 11, 12, 1 and 2) have the characters well marked, and resemble each other closely, but the body of No. I., that from the young male, is thin. In No. II. the body is unusually thick at the middle, gained by convexity of the superficial surface. No. VII. (figs. 8 and 9) presents a posterior tubercle projecting suddenly for $\frac{3}{4}$ inch on the cervical side, but with scarcely any projection on the distal side, giving the body a very abrupt commencement on the hinder edge. The want of an anterior tubercle tends to give the whole bone, in No. VII., a somewhat triangular appearance, but the body has the square form, broadening distally. The ovoid head is very oblique, with a pointed posterior end. No. III. (fig. 16) has a large and well-formed ovoid head. There is no distinction between neck and body, both tubercles being absent. The absence of the posterior tubercle was explained by the condition of the great posterior ligament, which was exceptionally broad and thin. This is the longest of these specimens. No. VI. resembles the last, but with a transition to the square form of body. The trochanter is represented only by a distinct roughness at the part. No. IV. (figs. 5 and 6) is the smallest of all these specimens, but has the characters well marked. The head is an ovoid, scarcely half an inch in length. The neck, well marked off at both ends, is very much bent, the convexity towards the pelvic bone. This bend is most marked on the left femur, in which the neck, which is also longer than that of the right, meets the body at nearly a right angle. The bend is opposite the trochanter, 1½ inch from the head. The concavity thus formed on the under surface is 1 inch in depth. The body is very square-shaped. No. X. has a close resemblance in form to No. IV., except that the neck is much less bent, and it is altogether a larger bone by from a fourth to a third.

No. V. (figs. 3 and 4) is the most anomalous of these specimens. The right has a short (3 inches long) square-shaped and very thick body; a neck as broad and thick as a thumb; and a good-sized head thoroughly anchylosed to the pelvic bone at the acetabulum. The left is free. Though at first view very irregular looking, this femur is simply a body, like the body of the right, but without a developed head or neck, these being represented only by a thin lamina, ¾ inch broad at the free end, projecting for ¼ inch outward from the body at the part where the neck should be. The *synostosis* of the right side is evidently of long standing, though this whale was probably not quite adult (44 to 45 feet long, and pelvic bone not quite finished behind), nor do the bones show any traces of disease. The form of the head is seen anteriorly and externally, the latter part projecting a little beyond the outer edge of the back part of the promontory of the pelvic bone; while, posteriorly, only a furrow marks where the anchylosis has taken place. Here the hinder edge of the acetabulum rises about ⅓ inch from the level of the surface of the pelvic bone before it reaches the place of anchylosis. The anchylosis involves also part of the neck posteriorly, but anteriorly the neck is free, and deeply between it and the pelvic bone there is a fissure into which the scalpel passes. On this side, therefore, a good sized head has been anchylosed in its socket, while, on the left side, the head and neck would seem to have become atrophied. The rudimentary head of the left side, however, naturally occupied the same position in relation to the pelvic bone as the anchylosed head of the right side does.

In No. VIII. (fig. 10) the body, marked off externally by a very distinct anterior tubercle and a slight posterior tubercle, expands so much distally as to have a decidedly triangular figure. The smallness of the trochanter accords with the anchylosed condition of the hip-joint. The *synostosis* must be of old standing, being very complete, and it is nearly symmetrical. I have met with an ostitic condition of the bones several times in this and in other species of the Cetacea, but here there are no traces of disease, and the form of the synostosis in this specimen, as well as the fact itself, is interesting. The place of anchylosis is not in a hollow, but on a platform projected from the pelvic bone. This platform is 3½ inches in length at the base, and has an elevation behind of ¾ inch, in front of ¼ inch. The base lies obliquely across the angular part of the pelvic bone, a little external to the middle, the hinder half of the base being opposite the promontory and reaching back to a little way internal to the usual position of the acetabulum, and there smoothly subsides. The place of union is marked by a shallow furrow, ⅛ inch or less in breadth, passing obliquely round. In length the place of union is 2 inches on both sides, in breadth 1 inch on the right, 1½ on the left side. The head and neck have somewhat broadened where they are soldered to the slightly concave top of the platform, but there is very little projection from the plane of the deep surface of the femur to meet the projection from the pelvic bone, on the left side none at all. On the left side the head is more sunk, though elevated enough to show its rounded outline; on the right side, the back part of the head projects obliquely for ½ to ¾ inch, like a rough finger-end, and is opposite the fore part of the recurved edge of the promontory. The platform above described may have followed or may have preceded the anchylosis, but if the heads in this case ever lay in the usual place of an acetabulum, they have been pushed forwards and inwards for fully 1½ inch by the growth of the platform. The direction in which the femur is anchylosed to the pelvic bone is not quite the same on the two sides, the left being more horizontal, so that its distal end is 1 inch behind that of its fellow; and more downwards, so that the interval between the end of the pelvic bone and the femur is ¾ inch on the right side and 1½ inch at the corresponding part on the left side.

No. IX. (fig. 7) is the thickest, and presents several strongly-marked characters. The head and neck are slender for so massive a specimen. The tubercle on the anterior border is strongly and abruptly developed, presenting a rough ovoid elevation $1\frac{3}{4}$ inch in length by $\frac{3}{4}$ inch in breadth. The trochanter begins abruptly on the cervical side, as in No. 7. The body is very thick, and somewhat prismatic, the third border, running as a sharp projecting edge along the deep aspect, from the trochanter to the distal end, nearly parallel to the anterior border and $1\frac{1}{2}$ inch from it. The end of the bone from which the distal cartilage has been detached, is oval, 4 inches by $2\frac{1}{4}$, the corners of the broader and partially flattened anterior end of the oval, being the parts to which the anterior border and the sharp ridge above noted run. The surface of the end presents a rough undulating hollow, caused mainly by the greater projection of the upper margin. This femur is much the heaviest of all these specimens, but had the anchylosis not prevented that of No. VIII. being weighed separately, it would probably have proved to be quite as heavy.

10. The column of weights, in Table II., also shows the variation among these thigh-bones. Among the adult specimens, those from the males are heavier than any among the females, but the difference between No. II., female, and No. VII., male, is not great. Nos. II. and III., female, are the longest of the whole series, and No. VI., female, would have been a large femur in the mature state. As this bone does not attach any of the muscles of the reproductive organs, we would expect that it should not present any fixed sexual characters, but that it would vary with the general muscularity. The weight of the femur is seen to vary from between about a third to about a fourth of that of the pelvic bone, but without a constant proportion; and in No. II. the heavier femur goes with the lighter pelvic bone. In No. VI., the least mature of the specimens weighed, the femur is not much under half the weight of the pelvic bone. The more advanced ossification of the femur accords with the observation of Reinhardt in the new-born *Mysticetus*, that ossification had begun in the femur, at its middle, while the pelvic bone was as yet entirely cartilaginous.

The *symmetry* of the femur, in these seven pairs, is notable, notwithstanding their great variation in form and size in different individuals. Except in No. V., in which the right is anchylosed, and in No. IV., in which the neck of the left is more bent, the differences between the right and left are but slight.

11. *The Cartilages of the Femur.*—The cartilage of the *head* varied in thickness in the different specimens, from $\frac{1}{10}$ or $\frac{1}{8}$ to $\frac{1}{4}$ or even $\frac{3}{8}$ inch. That of the distal end varied from $\frac{1}{10}$ to fully $\frac{1}{2}$ inch, generally thickest on the anterior half although the cartilaginous prominence (tibial condyle) supporting the tibia is on the posterior half. The distal cartilage in Nos. II. and VII. was only $\frac{1}{8}$ inch thick. In No. IV., $\frac{1}{8}$ to $\frac{1}{6}$. In No. III., at the tibial condyle $\frac{3}{8}$, anteriorly only $\frac{2}{8}$. In No. V., at the tibial condyle $\frac{3}{8}$, anteriorly $\frac{5}{8}$. In No. VIII., at the tibial condyle $\frac{1}{6}$ to $\frac{1}{4}$, anteriorly fully $\frac{1}{2}$ inch. In No. I., the young male, at the tibial condyle $\frac{1}{2}$, anteriorly $\frac{3}{4}$ inch. In this specimen the cartilage of the head was $\frac{1}{4}$ inch thick in front, $\frac{1}{8}$ behind. The thickness of the cartilages must not be judged of by the surface appearances, as they overlap the bone at the edges, concealing it may be as much as $\frac{1}{2}$ an inch of it. Sections must be made to see the true thickness at various parts.

The *periosteum* of the body of the femur is about $\frac{1}{8}$ inch in thickness.

III. The Second Appendicular Bone (The Tibia).

12. *Cartilaginous Condition.—Form.*—This element of the rudimentary limb is in all these specimens entirely cartilaginous. It is of a triangular or pyriform shape, articulating by an oval synovial surface on its base, with the cartilaginous condyle on the end of the femur, and tapering to a blunt apex about the size of the end of the little finger, from which a fibrous band is prolonged. The body is somewhat flattened, the surfaces superficial and deep, the borders inner and outer. The extreme length, from the anterior angle, or tuberosity, to the apex is, in the adult specimens from $3\frac{1}{8}$ to $4\frac{1}{4}$ inches; from the external angle, $\frac{3}{4}$ inch to 1 inch less. The greatest breadth, which is on a level with the external angle, is from $1\frac{1}{4}$ to $2\frac{1}{2}$, and the thickness at the same part is from 1 to $1\frac{1}{4}$ inch.

The *base* presents a shallow oval articular surface reminding one of the glenoid cavity of the human scapula. This surface measures 1 to $1\frac{1}{4}$ inch longitudinally, $\frac{3}{4}$ inch to 1 inch across. Beyond its raised margin is a narrow furrow, surrounded by the attachment of the capsular ligament of the joint. The end of the base slants obliquely upwards, so that the articular surface is seen on viewing the tibia from its deep, not from its superficial aspect. By this character the right tibia may easily be distinguished from the left. The anterior angle projects somewhat beyond the articular surface, forming a rounded projection (anterior tuberosity of the tibia) to which part of the tendon of the anterior muscular mass is attached.

The form of the *body* is somewhat variable. In No. VII., the longest of the specimens, the deep surface is convex both ways, the superficial surface flat, or a little concave transversely; the outer border concave behind the base and thinnest, the inner border undulating, with two concavities. In No. II., the outer border is mostly convex, the inner mostly concave; both surfaces are about equally convex transversely, and the left tibia is $\frac{1}{2}$ an inch longer than the right. In No. V., the base is so large that both borders are concave, the right tibia (the side on which the femur is anchylosed to the pelvis) is $\frac{5}{8}$ inch longer than the left, and is narrower than the left, so as to be almost round; both are more convex transversely on the superficial than on the deep surface, and both are bent longitudinally, the concavity on the deep aspect. No. IV. is nearly straight, the undulations on the borders slight, and is so equal as almost to appear a round elongated cone, cut obliquely at the base.

Variations in the flexibility of these tibiæ are mainly due to the differences in form. Allowing for this, those of the adult males are perhaps the least flexible, but the left tibia of No. II. is as dense as they are, while the right is softer and more flexible. In the young male (No. I.), the cartilage is so soft that it may be bent so as nearly to make the ends touch.

The above measurements include the *perichondrium*. This fibrous capsule is about $\frac{1}{6}$ inch thick on the surfaces, thicker at the borders. It is not very easy to fix the limit between the perichondrium and the fibrous structures attached to it, but what may be regarded as the perichondrium proper is from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick along the borders, thickest at the outer border. The cartilage proper is, therefore, not so large as in the measurements given, except in length. From the breadth fully $\frac{1}{2}$ an inch, and from the thickness $\frac{1}{3}$ inch may be deducted. In sections the cartilage is seen to be traversed by an abundance of vascular canals.

(B.) THE LIGAMENTS, ARTICULATIONS, AND MOVEMENTS OF THE FEMUR AND TIBIA.

I. THE KNEE-JOINT.

13. A well-marked synovial cavity was found between the femur and the tibia in all these dissections. The adaptation of the end of the tibia so as to form an oval glenoid articular cavity has been described above. On the femur the distal cartilage presents a corresponding oval elevation, which may be termed the *condyle;* 1 to $1\frac{1}{4}$ inches in length, antero-posteriorly, $\frac{3}{4}$ to 1 inch across; convex in both directions but more especially across; and placed towards the hinder part of the bone. The end of the femur, covered by its cartilage, presents two parts sloping in opposite directions from a more or less projecting angle, the posterior supporting the articular condyle, the anterior occupied by fibrous and muscular attachments, and invested by a thin perichondrium. The angle between the two slopes is greater in the natural state than on the macerated bone, from the projection of the anterior end of the condyle. When the cartilage is dried on the bone, the articular condyle still stands out as an oval elevation with well-marked edges.

The *synovial membrane* extends a little boyond the condyle and cavity, lining a surrounding furrow, to the outer part of which the capsular ligament is attached. The synovial membrane may be dissected off both of the cartilaginous articular surfaces; on the condyle of the femur it may even be pinched up with the forceps, and, after it is removed, a thin perichondrial layer may next be dissected off. No. V. presented, equally on both sides, an exceptionally extensive synovial surface, 2 inches in length on both tibia and femur; the breadth, $1\frac{1}{4}$ on the femur, $1\frac{1}{8}$ on the tibia. The condyle and glenoid cavity were $1\frac{1}{2}$ inch in length, the anterior $\frac{1}{2}$ inch of synovial membrane lying on soft tissue, in contrast with the firm polished cartilage of the condyle.

The *capsular ligament* surrounding the cavity is thick. It was generally thicker on the deep aspect ($\frac{1}{4}$ to $\frac{1}{2}$ inch thick) than on the superficial ($\frac{1}{8}$ to $\frac{1}{4}$ inch), thicker at the hinder angle ($\frac{3}{4}$ inch); at the anterior angle, of indefinite thickness from continuity with the tendinous insertions. In No IV., in which the cavity was small (length 1 inch, breadth $\frac{5}{8}$) it was $\frac{1}{2}$ inch thick all round. In No. V., in which the synovial cavity was large, the ligament was $\frac{1}{6}$ inch thick along both sides, $\frac{1}{2}$ inch at the hinder angle.

As noted with the tibia, the plane of this joint is oblique, so that when the tibia is pressed upwards, it rests obliquely upon the femur, but the opposition is mainly when the tibia is pressed outwards. It is at the same time a shallow ball-and-socket joint. The surfaces permit of inward and outward motion of the tibia (extension and flexion of the knee), and of gliding movements in any direction, but the adaptation appears to be for forward and backward gliding rather than for flexion and extension, and the direction of the two opposing muscular powers accords with this.

II. The Hip-Joint and the Ligaments of the Femur.

14. *Position and Movements of the Femur.*—The *position* of the head and shaft of the femur in relation to the pelvic bone is important as bearing on the arrangements of the hip-joint and the direction of the ligaments and muscles. The following indications have also enabled me to have the bones articulated and sketched in their natural relative position. The *head* generally projects beyond the outer edge of the pelvic bone. The following measurements include the cartilage on the head. The extent of the projection was, in No. III., $1\frac{1}{2}$ inches; in No. II. and No. VI., $\frac{3}{4}$; in No. I., $\frac{5}{8}$; in No, IV., in which the head is small, and in No. V., in which the head is much reduced, in each $\frac{1}{4}$ inch. In some the head is placed entirely within the edge of the pelvic bone. In No VII. it was from $\frac{1}{4}$ to $\frac{1}{2}$ inch within, and the form of the macerated bone shows that it must have been so. In No. XI. also, the sharp crescentic outer edge of the acetabulum shows that the head cannot have projected. In No. VIII. (both thigh bones anchylosed), the original position of the head must have been quite within.

The position of the *shaft* is best indicated by taking its relation to the anterior border of the beak, at about their middle. The anterior border of the femur at that part is generally behind that of the pelvic bone about 1 inch, or less. The shape of the femur and the direction of the beak cause variations of this relation. In Nos. III. and VII. it was $1\frac{1}{4}$ inch; in No. IV. only $\frac{1}{4}$ inch; in No. II. they were on the same level, the beak being nearly horizontal. In No. V., on the anchylosed side, the anterior border of the femur is nearly on a level with that of the beak, while on the left side it was about 1 inch farther back.

The *movements* of the femur require to be defined, before proceeding to consider the actions of the ligaments and muscles. The movement of the hinder edge and trochanter away from the cross part of the pelvic bone is rotation inwards; the opposite, rotation outwards. The forward movement of the shaft is flexion; the opposite, extension. Carrying the distal end of the femur downwards, towards the skin, is abduction; carrying it closer to the beak is adduction. There are also gliding motions of the femur obliquely inwards and obliquely outwards, in the direction of the bone. But all of these movements are naturally very limited. The ligaments are still entire on the left side of No. I., the half grown male, and permit these movements to the following extent. (*a.*) From extreme flexion to extreme extension, the distal end of the femur has moved $\frac{2}{8}$ inch. (*b.*) From extreme adduction (contact with the beak) to extreme abduction, the distal end moves $\frac{4}{8}$ inch, but the movement is naturally much less as the femur is separated from the beak by muscles and other soft tissue. When combined with rotation inwards, the abducting movement is more free, carrying the anterior border $\frac{7}{8}$ inch away from the beak. (*c.*) From extreme rotation inwards to extreme rotation outwards, the distal end, at the posterior angle, has moved $\frac{6}{8}$ inch; taken at the middle of the posterior border of the body, the extent is $\frac{4}{8}$ inch. (*d.*) The extreme extent of the gliding movement is $\frac{1}{8}$ inch. But these movements are more free now in the dissected specimen, than when the femur was padded by the muscles, areolar tissue and fat. In the early stages of the dissections the femur could just be felt to move. In No. V., which was preserved ligamentous for a time, it could barely be felt to move on the non-anchylosed side. Anchylosis of a joint so little movable is not surprising. My impression as to the gliding movement, however, is that, in some of the specimens, it was more free than above noted in No. I.

15. *The Ligaments.*—The ligaments connecting the femur to the pelvic bone may be arranged as those of the head and those of the body of the femur, and each of these groups subdivided into the posterior and the anterior. The posterior ligaments are two in number, the greater for the body, the lesser and shorter for the head.

(*a.*) The *great posterior ligament* (figs. 11 and 16*a*), arises from the dividing ridge of the under surface of the body of the pelvic bone, and is inserted into the posterior tubercle of the femur (trochanter) and into the border on each side of it. It is from 8 to 10 inches in length according to the size of the subject, its origin not extending on the posterior fourth of the body. Beginning as a flat ligament, it becomes gradually thicker, and in its anterior half or third, where it has left the pelvic bone, it is rope-like and as large as a thick thumb. The point of attachment of this great ligament accounts for the presence of the tubercle representing the great trochanter. The extension of the insertion a little on each side of the trochanter gives a breadth of about 1½ inch at its attachment to the femur. In No. III. the whole ligament was expanded into a broad thick triangular membrane, attached to 6 of the 9 inches of the hinder edge of that femur, the fore part of the ligament arising from the ligament of the head, with which it formed a continuous sheet. This arrangement in No. III. accounts for the absence of the trochanter on that femur. Besides checking rotation inwards and also inward gliding of the femur, the great function of this ligament is manifestly to check flexion, to resist the forward traction of the great trunk mass of muscle. In No. V., however, in which the femur on the right side was anchylosed to the pelvis, the anchylosis evidently of no recent date, the ligament was large and little if at all smaller than on the side on which the femur was movable. The traction of the muscular fibres which arise from it may have sufficed to maintain the condition of the ligament.

(*b*.) The *posterior ligament of the head* (figs. 11 and 16*b*) is attached in front to the hinder edge of the head and neighbouring part of the neck, and reaches back for 3 inches or more on the pelvic bone. In form it is a thick strap (may be ¾ inch broad and ¼ thick), increases in breadth forwards, and leaves the pelvic bone at a variable distance from the femur. It may join the great ligament by an expansion but usually there is an interval. The direction of the great ligament is forwards and a little inwards, the direction of this ligament is forwards and outwards, at last projecting beyond the pelvic bone to reach the projecting head. This ligament checks rotation inwards, outward gliding, and extension. In flexion and extension, when the body of the femur moves forwards the head moves backwards, the bone moving on its neck, hence of the two posterior ligaments, one checks flexion the other extension.

(*c.*) The *anterior ligament of the head* (figs. 11 and 16*c*) arises from the promontory about 1 inch in front of the head of the femur, and passes back enveloping the head on its under, outer, and upper aspects for a breadth of about 2 inches, like part of a capsule. The direction of its outer part is obliquely outwards, according to the projection of the head, that of the inner fibres, on the superficial aspect, obliquely inwards, the most internal running a little way on the neck where they may form a special band. The outer part checks flexion, the inner extension, the head being carried in opposite directions. The under part checks rotation outwards, and outward gliding is checked by the whole ligament except the part to the neck. In No. VII., in which the acetabulum is deep and the head placed inwardly, this ligament was in the form of a membrane $2\frac{1}{4}$ inches broad where it arose from the sharp crescentic edge of the acetabulum, and passed inwards on the superficial aspect to be inserted, $2\frac{1}{2}$ inches in breadth, along the head and neck of the femur: the part to the neck was specially developed, representing probably the next ligament. When the head projects much, as in Nos. I. (figs. 11 and 12) and III. (fig. 15), the entire ligament is directed outwards.

(*d.*) *The anterior ligaments of the body* of the femur may be conveniently termed interosseous. They are two in number, one external (figs. 11 and 16*d*) passing obliquely from the promontory inwards to the femur; the other, internal (fig. 16*e*) passing from the beak obliquely outwards. The *external* arises from the inner side of the pelvic promontory, sometimes partly overlapped by the inner fibres of the last ligament, passes obliquely inwards and backwards and is attached to the anterior part of the deep surface of the body and neck of the femur, opposite to the attachment of the great posterior ligament, but reaching more externally. It is a strong ligament, square-shaped and short, averaging about 1 to $1\frac{1}{2}$ inch in breadth, $\frac{1}{3}$ in thickness, and $\frac{3}{4}$ in length. It checks extension, rotation outwards, and also inward gliding of the femur. The *internal* interosseous ligament is more expanded and membranous. Its attachment to the beak is for about 3 inches in breadth, beginning about 1 inch from the bony tip. The fibres, after slanting obliquely outwards, are attached along the deep surface of the body of the femur, at a variable distance between the anterior and posterior borders. The outer part is the strongest, and may pass out on the neck, even as far as the head. This ligament checks extension and outward gliding. These two ligaments have a close relation to the two interosseous muscles. The internal lies either within or on the under aspect of the deep muscle, gives attachment to many of its bundles, and might be regarded as in part belonging to the muscle, but its outer part is more of the nature of a ligament. The external lies on the deep aspect of the corresponding muscle and is a strong ligament.

(*e.*) *The ligaments by which each movement is checked.*—The various movements are checked as follows. *Flexion*, by the great posterior ligament, and the anterior ligament of the head. These will be assisted by the great superficial aponeurosis and by the tibial band, yet to be described. *Extension*, by the two anterior ligaments of the body (interosseous), and by the posterior ligament of the head. *Rotation inwards*, by the two posterior ligaments. *Rotation outwards*, by the anterior ligament of the head, and the external interosseous ligament. *Outward gliding*, by both of the ligaments of the head, and by the internal interosseous ligament. *Inward gliding*, by the great posterior ligament, and the external interosseous ligament. Looking to the muscles, the direction in which movement most requires to be checked is forwards, with some inward gliding, and associated with these is the tendency to rotation inwards. Hence the great size of the great posterior ligament, which is so placed as to check these three movements.

Were the structures corresponding to the three great bands of the human hip-joint to be sought for here, we might recognise, in the great posterior ligament, the ischio-femoral band; in the external interosseous ligament, the ilio-femoral band; and in the outer part of the internal interosseous, the pubo-femoral band.

16. *The Synovial Cavity of the Hip-Joint.*—The synovial membrane is situated at the anterior part of the deep aspect of the head, extending a little way on the neck. It may reach also on the anterior part of the outer end of the head. It is more extensive on the pelvis than on the femur. On the pelvis it is elongated antero-posteriorly, on the femur generally transversely, as it covers only part of the head and extends in on the the neck. It may be as large as 2 inches by $1\frac{1}{4}$, or as small as $\frac{3}{4}$ by $\frac{1}{2}$ inch, and there may be an additional synovial cavity. The membrane is distinct all round, at the reflexions and over

the articular surfaces. It can be pinched up and dissected off the cartilages, and lies loosely on the fibrous and fatty bed beyond the cartilages.

17. *The Acetabular Cartilage.*—This interesting cartilage might at first be mistaken for a growing cartilage of the promontory, but it is behind the prominence and spreads backwards and inwards to floor the articular cavity, and is evidently the cartilage of the acetabulum. Only part of it is seen when the synovial cavity is opened, appearing as the cartilaginous socket. To see it fully the thicker areolar tissue and the thicker perichondrium beyond should be stripped off. It is of an ovoid form, the more pointed end behind, and may be from $1\frac{1}{2}$ to 2 inches in length, antero-posteriorly, and $\frac{3}{4}$ to 1 inch in breadth. It projects a little beyond the outer edge of the bone, and this part of it comes in relation with the fibrous edging before noticed as skirting the margin of the pelvic bone. The limits of this cartilage are seen in figs. 11 and 12, and its place on the macerated bones is seen in figs. 1, 3, and 5.

18. *The Variations and Adaptations of the Hip-Joint.*—Although in *Mysticetus* there is a head and more or less of a socket, there is not the condition of a ball working in a resisting socket. On the contrary the head of the femur generally lies out of the socket, in the position which in human surgery we would call dislocation backwards. The femur lies nearly parallel to this part of the pelvic bone, pressing close on it near the head. It is only the deep aspect of the head which can come in relation with the pelvis, and it is the outer part of the neck rather than the head which bears the pressure and which forms the pivot on which the femur moves. In this reduced condition of function we would expect to find great variation presented by the parts at the hip-joint. The more noteworthy of these, with their adaptations in the several specimens, will now be considered.

(*a.*) No. I., the half-grown male (figs. 11 and 12) will be more particularly noticed, as it afforded the best opportunity for complete examination. On the right side, the *acetabular cartilage* is fully exposed. It projects considerably outwards beyond the pelvic bone, towards the fore part as much as $\frac{1}{2}$ inch; and at the same time projects downwards externally to form the edge of the acetabulum. Thus in transverse section it is prismatic; where it is thickest the attached surface and the dorsal surface each $\frac{5}{8}$ inch, the acetabular surface $\frac{6}{8}$. The total length is $1\frac{3}{4}$ inch, but only the hinder two-thirds form the cavity, the anterior third forming a prominence receding from the fore end of the cavity to a little way behind the middle of the promontory. The cavity is ovoid in form; length $1\frac{1}{4}$, breadth $\frac{3}{4}$ inch; concave in both directions, depth of concavity about $\frac{1}{6}$ inch longitudinally, transversely very little; at outer edge it is slightly convex transversely. The direction of the groove of the cavity is obliquely forwards and a little inwards, in adaptation to the neck of the femur. There is thus formed a grooved cartilaginous bed adapted to receive the neck of the femur near the head, against the outer edge of which the inner edge of the head rests. The cartilage in this half-grown male is much thicker than in any of the other specimens. The extent to which this cartilage may ossify will affect the direction and form of the acetabulum on the macerated bone. Were it removed the surface of bone which supports it would recede from the level of the under surface of the bone somewhat as it does in Nos. VI. and V.; were it wholly ossified the acetabulum would not have the cup shape presented by Nos. VII. and XI., but merely the grooved prolongation behind the recurved back of the promontory which most of the specimens present.

The cartilage on the *head of the femur* is on the back part $\frac{1}{8}$ inch thick, on the fore part $\frac{1}{4}$ inch, and receives here the anterior ligament of the head. The *synovial membrane* lines the acetabulum behind for 1 inch antero-posteriorly by $\frac{1}{3}$ inch transversely. On the femur it covers the anterior and inner part of the deep aspect of the head, and reaches in for nearly half an inch on the neck. The synovial membrane at the neck lies on areolar tissue, this again on ligamentous tissue prolonged from the deep fibres of the anterior ligament of the head, and this on the periosteum of the neck. The exact *adaptation*, then, is that the broad oblique cartilaginous groove representing the acetabulum, receives the back of the obliquely directed neck of the femur, which is convex antero-posteriorly and fits the groove well and easily, abutting at the fore part against the cartilaginous prominence. The inner edge of the head lies exactly parallel to and closely fits the extreme fibrous edging of the pelvis which skirts the acetabular cartilage, and therefore hardly far enough in even to touch the outer edge of the cartilage except by its fore part. Hence the synovial membrane lines only the inner side of the fore part of the deep aspect of the head, besides covering part of the neck. It is therefore the neck not the head on which the femur plays, cushioned by fibrous and areolar tissue in addition to its periosteum and lubricated by a synovial membrane.

On both sides there is an *additional synovial cavity* in front of the head and concealed by the anterior ligament of the head; on the left side $\frac{5}{8}$ inch in length, on the right side larger, but I am uncertain whether they did not communicate with the larger cavity.

As the synovial cavity of the hip-joint is exposed on the outside and behind without dividing any of the ligaments, it might at first be regarded as outside the capsule, and therefore as an outside bursa mucosa rather than a true synovial cavity of the hip-joint, but the true comparison to the fully functional joint rather is that the head in *Mysticetus* is as it were dislocated backwards between the ilio-femoral and ischio-femoral bands (see paper by the author on the

Ligaments of the Hip-Joint in Man, *Edinburgh Med. Jour.* 1858), the part of the capsular ligament between these two bands being here wanting, so that the joint is left uninclosed externally except by the aponeurosis of the muscles. The cartilage of the head of the femur thus protruded is covered, except for about the fourth part of its deep aspect where it is lined by synovial membrane, by a soft cushiony perichondrium, and surrounded by loose areolar tissue which enables it to move within the adventitious capsule formed by the aponeurosis of the muscles. The cartilage of the head therefore performs but very partially the function of an articular cartilage.

(*b.*) In Nos. II., III., IV., V., and VI. the acetabulum presents the same type as in the last, a broad groove more or less shallow, corresponding or opposite to the neck of the femur. On the macerated bones the *place of the acetabular cartilage* is seen as a rough more or less excavated ovoid or elliptical area, most pointed behind; and the place where that cartilage projected beyond the bone is marked as an eroded edge, with a rather abrupt posterior beginning at $1\frac{1}{2}$ to 2 inches behind the promontory. The acetabular cartilage was not thicker than $\frac{1}{10}$ to $\frac{1}{8}$ inch.

(*c.*) In No. III. (figs. 16 and 17) the same general adaptation is seen as in No. I., except that the acetabular cartilage does not become thick externally, the surface here becoming rounded off transversely; nor does it thicken anteriorly, there being here but a cartilaginous covering on the back of the well-recurved promontory. The synovial area on the pelvis was $1\frac{3}{4}$ by 1 inch, the cartilaginous socket only $1\frac{1}{4}$ by $\frac{1}{2}$ inch, but the whole acetabular cartilage when exposed was $2\frac{1}{4}$ by 1 inch. On the macerated bone what was the articular socket is seen on the hinder and inner part of the general area of the acetabular cartilage, close to the outer edge of the bone, which it excavates considerably. Depth of the hollow antero-posteriorly $\frac{1}{6}$ inch. Transversely it is convex. Taking in the whole area, the hollow is deeper, $\frac{1}{4}$ to $\frac{1}{3}$ inch antero-posteriorly. On the femur the synovial surface is 1 inch antero-posteriorly, only $\frac{6}{8}$ transversely. It covers the anterior half of the deep surface of the head and a little of the neck. Outwardly it does not reach farther on the head than to $\frac{1}{2}$ inch from the extreme end. The cartilage of the head is continued farthest in on the deep aspect. As far as can now be determined the inner side of the fore part of the head lay in adaptation with the outer slope of the socket and on the external bordering fibrous tissue, much as in No. I., but the projection beyond the pelvis was greater than in No. I. according to the measurement made when the parts were in connection.

(*d.*) In No. VI. the parts were so rotten that I could not be sure whether a cavity, about $\frac{1}{2}$ inch in diameter, between the fore part of the head and the edge of the acetabulum, was a synovial cavity or only a large oil cavity of decomposition. The cartilages were not examined, but the macerated bones of this not full-grown specimen show exactly where they lay. There is the same general form of both bones as in Nos. I. and III., but the head of the femur does not enlarge so much as in No. III. Its cartilaginous area ($1\frac{1}{4}$ by $\frac{1}{2}$ inch) is entirely terminal, not reaching at all on the deep aspect. The long flattened neck is convex both ways; the last $\frac{3}{4}$ inch, which may be assigned partly to the neck partly to the head, is flat longitudinally. On the pelvis, there is a strongly recurved promontory, giving an elevation $1\frac{1}{2}$ inch in length transversely, and bounding a deep non-articular hollow in which the neck of the femur lies. The cartilaginous area on this eminence is $1\frac{1}{4}$ by fully $\frac{1}{2}$ inch, facing obliquely backwards, so that the cartilage must have farther deepened the non-articular hollow. But the acetabulum proper has been on the outer edge, formed by the cartilage bending back here nearly at right angles as the mark shows. This part of the area is 1 inch by $\frac{1}{4}$, facing outwards and a litle downwards. The back of the femur, where the neck and head meet, would press against this cartilaginous edging, and the whole arrangement, osseous and articular, is well-adapted to determine or to allow the various motions already defined. The cartilage-mark in this specimen might readily have been taken for that of a growing cartilage of the promontory.

The acetabulum in these three specimens may be defined as presenting the deeply-grooved type. In the next three it is comparatively shallow.

(*e.*) In No. II. (figs. 1 and 2) the bony acetabulum is very shallow (depth longitudinally about $\frac{1}{8}$ inch, transversely $\frac{1}{20}$), the promontory being very little recurved, and is placed entirely on the under surface, not reaching the outer edge except for a little behind. Synovial surface on pelvis $2\frac{1}{8}$ inch by $1\frac{3}{4}$; cartilaginous socket $1\frac{1}{4}$ by $\frac{6}{8}$, but the cartilage extends $\frac{1}{8}$ inch farther all round. This shallow cavity presents behind the middle a low mound, with a hollow before and behind it. The head of this femur is very flat, distinguishable from the neck only by its roughness and slight expansion. The head and neck on their deep aspect are quite flat antero-posteriorly and a little concave transversely. The cartilage on the end of the flattened head was $\frac{3}{8}$ inch thick, and sent an expansion inwards on the deep surface for $\frac{6}{8}$ inch. The macerated bone presents a corresponding roughness on the edge and deep surface, marking off what may be assigned to the head. The synovial area was 1 inch antero-posteriorly, $1\frac{3}{8}$ transversely. About the outer half of this lay on the cartilage, presenting a rounded articular surface $\frac{6}{8}$ inch in diameter, its outer limit $\frac{3}{8}$ inch from the extreme outer end of the cartilage-covered head. The adaptations are exact. The femur, by its rounded articular surface on the deep aspect of the head, presents a hollow, which rests and plays on the low mound of the acetabulum. In the rotatory movements of the shaft, the fore and hind edge of the head sink into the acetabular hollows, respectively before and behind the mound. The antero-posterior extensions of the synovial sac allow the head, rotating on the mound, to move respectively forwards or backwards as the shaft moves in the opposite direction. This was on the right side. On the left side, the adaptations were nearly the same. Almost the whole of the synovial membrane on the femur was cushioned by a layer of fat, $\frac{1}{6}$ inch thick, beneath which lay a cartilage as on the right side. On the macerated bone the head is seen to be a little longer and less expanded than on the left side and as if the cartilage had extended less inwards on the deep surface.

(*f.*) In No. IV. (figs. 5 and 6) the position is, that the much bent neck, external to the bend, lies in the shallow non-articular hollow behind the promontory, a cushion of areolar and fibrous tissue, $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, intervening; and that the narrow neck and head, the latter projecting $\frac{1}{4}$ inch beyond the pelvis, can be in contact with a socket only for $\frac{1}{2}$ inch antero-posteriorly. The synovial cavity was small ($\frac{6}{8}$ by $\frac{4}{8}$ inch), oval with the long axis oblique inwards and forwards. At the femur, on the left side, it touched the cartilage of the head; on the right side, it lay opposite the anterior half of the deep aspect of the head, and partly on the neck. On the pelvis there was at first almost no appearance of a cartilaginous socket, but on removing the synovial membrane and perichondrium, a good-sized acetabular cartilage ($1\frac{3}{4}$ to 2 inches by $\frac{1}{2}$ inch) came into view, as now seen on the macerated bones. The anterior half, convex both ways, is on the hinder slope of the promontory. The hinder half, where the femur touches, is narrow, concave longitudinally, convex transversely, and slightly notches the outer edge of the bone. The bent form of the neck seems to have removed the femur from much pressure on the acetabular edge, so that no socket had been formed beyond a synovial membrane. Above the convex neck of the femur was a cushion first of areolar tissue and then of fibrous tissue, $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, on which the femur moved and by which pressure of the femur against the pelvis was borne.

(*g.*) The bones of No. X. (a not very large and probably not full-grown female) were cleaned before they reached me. But the place of the acetabular cartilage is well-marked and its area closely resembles in position and form that on the macerated bones of No. IV. The promontory in front of the acetabular area is less recurved than in any of the other specimens, as if not yet fully formed. The end of the beak is incompletely ossified, but the posterior end of the body has a finished appearance.

(*h.*) In No. V. (figs. 3 and 4) a synovial sac, about $\frac{3}{4}$ inch diameter, lay on the deep aspect of the stunted head of the femur, separated from it by prolonged ligamentous fibres and loose areolar tissue. There was no articular socket, but on removing the coverings, the acetabular cartilage came into view. As the mark on the macerated bone shows, it was 2 inches by $\frac{3}{4}$ inch, commencing at the middle of the promontory, and tapering backwards; situated on the thickened outer border of the bone, facing obliquely downwards and outwards, convex both ways, except behind, where it is a little concave and narrow. This narrow part was opposite the outer and anterior part of the synovial sac. In this specimen the head, neck, and neighbouring part of the body of the stunted femur, appear to have moved on the areolar and fibrous tissue of the shallow general excavation of the pelvic bone. *Another synovial sac*, 1 inch in diameter, was found close behind the first, between the pelvic bone and the prominence caused by a greatly developed trochanter, covered by the ligaments inserted into it. It had no cartilage, and I was uncertain whether it did not communicate with the sac in front of it. On the right side, although there is old standing anchylosis of the hip-joint, the mark on the macerated bone shows that the cartilage has survived the anchylosis on the outer side, in two patches, the posterior (1 inch by $\frac{3}{4}$ inch) opposite the anchylosed head, the other ($\frac{3}{4}$ by $\frac{1}{2}$ inch) on the back of the promontory. They correspond to where the greater part of the cartilage lay on the non-anchylosed side.

(*i.*) No. VII. (figs. 8 and 9) presents the best example of the cup-shaped type of acetabulum. On the bone it is seen to be bounded in front by a strongly incurved and recurved promontory, and externally by a crescentic ridge continued from the promontory to the outer margin of the body. Besides this there is a deep excavation of the bone, bounded on the inner side by a smooth edge, more marked at the inner and fore part, least defined posteriorly where its beginning is gradual It is oval in form, about 2 inches antero-posteriorly, $1\frac{1}{2}$ transversely; greatest depth, transversely $\frac{1}{2}$ inch, antero-posteriorly $\frac{5}{8}$ inch. Speaking generally, it would hold half of a good sized hen's egg cut long ways. The only part of this great cavity lined by cartilage and synovial membrane was a small oval patch in front ($\frac{7}{8}$ inch long, $\frac{3}{8}$ inch broad). The place of this is well seen on the macerated bone, as a rough oval slightly raised platform, at the fore and outer part, its superficial edge forming part of the edge of the acetabulum. The rest of the bony acetabulum is smooth and non-articular. On the large and obliquely placed head of the femur the cartilaginous area ($1\frac{3}{4}$ by 1 inch) is placed on the end, convex both ways, but not prolonged either on the deep or superficial aspects. The synovial sac ($1\frac{1}{8}$ inch longitudinally, $\frac{6}{8}$ inch transversely) lay upon this, the deeper half between the head and the cartilaginous part of the acetabulum, the more superficial half between the head and the capsular ligament. The rest of the acetabulum was occupied by stringy areolar tissue passing between the two bones. When the bones are placed naturally together, the head is seen to be fully half sunk in the socket, and entirely so when the femur is rotated inwards, and then the oblique superficial margin of the head fits exactly the crescentic edge of the acetabulum. The outer crescentic wall quite prevents the head of the bone from gliding outwards, but the adaptations allow of the other motions already defined. Pressure of the head against the cartilage of the socket will take place most in the movements of the shaft forwards and backwards, but also in the other movements. The form of the acetabulum is compatible with much more extensive movements forwards and backwards, and of rotation, than the ligaments will allow. As already referred to, this ball and socket form of the joint was accompanied by a modification of the anterior ligament of the head into the form of a capsular ligament on the superficial aspect of the joint, assisting to confine the head in the socket. When the femur is rotated outwards, the very abrupt outer side of the trochanter, in this specimen, is seen as if adapted to fit on the inner edge of the pelvic bone.

(*j.*) The pelvic bone, No. XI., shows a less marked example of the cup-shaped acetabulum than the last. Cavity oval antero-posteriorly, $2\frac{1}{2}$ inches by about $1\frac{1}{4}$; depth antero-posteriorly $\frac{1}{2}$ inch, transversely only about $\frac{1}{6}$ inch from the want of a high inner boundary. From the well-recurved promontory the outer lip sweeps outwards and backwards in nearly a semicircle, coming in rapidly behind, so that this large cavity is entirely supported on a bony projection external to the line of the posterior division of the pelvic bone. The outer side of the cavity rises to a sharp-edged boundary, a form which the cartilage presented by the half-grown male, No. I., prolonged and ossified, would produce. There is no indication of the cartilage having been confined to any particular part of the acetabulum. This form of acetabulum is incompatible with a projecting position of the head or with outward gliding. It is adapted to contain a large ovoid head, like that of No. VII. This characteristic specimen of the right pelvic bone of an adult female *Mysticetus* was picked up on the shore at Davis Straits.

(*k.*) The bones of No. IX. were cleaned before they reached me. The stunted condition of the beak is noted in section 4. The part which was still covered by the acetabular cartilage, now a rough depression on the bone, is seen in the drawing (fig. 7). It is situated obliquely on the foremost part of the under surface of the promontory, $1\frac{1}{4}$ inch in length, $\frac{5}{8}$ inch in breadth, and is quite flat. This area corresponds well to the back of the head of the femur. The head has the usual oblique direction, forwards and inwards, and the mark of its cartilage shows that it has been more broadly covered by cartilage on this surface than on the under surface. If this, as seems likely, was the adaptation, the femur, placed almost transversely, would conceal all the stunted beak except the root. Such a beak cannot have afforded extensive support to the body of this massive femur, but it now, in the bony state, fits pretty well against the anterior of the two deep surfaces of the prismatic body, and when the femur is moved a little backwards, the blunt point of the beak comes against a special projection on the femur, opposite the inner end of the anterior tubercle.

(*To be continued.*)

EXPLANATION OF PLATES XIV. to XVII. (All the figures are reduced to $\frac{1}{6}$.)

Figures 1, 3, 5, 8, and 10, show the pelvic bone, *P*; the femur, *F*; and the tibia, *T*; of the left side, from five Right-Whales; seen on the under aspect, and placed in their natural relation, except that the tibia is a little separated from the femur. Figs. 2, 4, 6, and 9, show the femur belonging respectively, to figs. 1, 3, 5, and 8 seen edge-ways from before; the surface in relation with the pelvic bone uppermost. Fig. 7 shows the pelvic bone and femur of the right side, from another Right-Whale, the femur raised from the pelvic bone. The shaded parts at both ends of the femur, and at anterior end of the beak of the pelvic bone, show the rough parts, on the macerated bones, which were covered with cartilage. The like marking on the promontory, in figs. 1, 8, and 10, are merely rough surfaces which did not support cartilage. The longitudinal line on the body of the pelvic bone in figs. 1, 3, 5, and 8, shows the position of the longitudinal dividing ridge.

Fig. 1. From Whale No. II., female 58 to 60 feet long. On the *pelvic bone*, *a*, body; *b*, beak; *c*, angle; *d*, promontory; *e*, acetabular area, partly above and below, partly concealed by head and neck of femur. On the *femur*, *g*, head, succeeded by the neck; *h*, trochanter; *i*, anterior tubercle; *k*, tibial condyle. On the *tibia*, *m* and *n*, anterior and posterior angles of the base, the articular surface not seen owing to its oblique plane.

Fig. 2. Femur of same, seen from anterior margin. The position of the anterior tubercle is marked.

Fig. 3. From Whale No. V.; female 48 feet long; *g*, very reduced head; *e*,

acetabular area, marked by dotted line. Femur of right side of this whale was anchylosed to pelvic bone at hip-joint. This fig. and fig. 1 show the characteristically broad and flat posterior end of the pelvic bone in the female.

Fig. 4. Femur of same, seen from anterior margin, and a little from under aspect, to show prismatic form of the bone, and the extreme thinness of the reduced head. The line shows the exact anterior margin.

Fig. 5. From Whale No. IV.; female about 62 feet long; *e*, acetabular area, so far as not concealed by neck of femur.

Fig. 6. Femur of the same, seen from anterior margin, showing very bent form of this femur where neck and body meet. The trochanter is seen to project upwards as well as backwards.

Fig. 7. From Whale No. IX.; a large male; *o*, rough surface on abrupt posterior end of body, for attachment of interpelvic ligament; *e*, acetabular area on promontory, marked by dotted outline; *b*, exceptionally short and narrow beak; the femur raised from natural position to show beak; *i*, very marked and rough anterior tubercle on this femur; *p*, deeply excaved end of femur which had supported distal cartilage.

Fig. 8. From Whale No. VII.; male 48 feet long. Shows head of femur lodged in a deep acetabulum, overhung by a rough reverted ledge of promontory. Characteristic distal end of femur, anterior third bevelled for muscular attachment, posterior two-thirds supporting knee-joint; the whole rough where it was covered by distal cartilage of femur. Tibia showing characteristic form, anterior and posterior angles at base, and undulations on the borders, two concavities on inner, one on outer, border.

Fig. 9. Femur of same, seen from anterior margin. The roughness on large and well-formed head shows where it was covered by cartilage. At distal end, roughness on bevelled anterior third, as seen from before.

Fig. 10. From Whale No. VIII.; male, of good size, but not of largest size; *g* dotted line showing where head is firmly anchylosed to pelvic bone. The two lines, *g*, converging behind the head, mark projecting platform of pelvic bone on which femur is anchylosed; femur of right side was similarly anchylosed; *o*, rough surface on abrupt posterior end of body for attachment of interpelvic ligament. Thick rounded form of body, characteristic of male pelvic bone, seen in the three figures, 7, 8, and 10.

Figs. 11 and 12. From Whale No. I.; half-grown male, 35 feet long. Under and upper views showing pelvic bone, femur and tibia, and their ligaments, the interpelvic ligament, and relation of penis to pelvic bone.

Fig. 11. Under view; *P*, pelvic bone; *F*, femur; *T*, tibia; *a*, great posterior ligament of body of femur; *b*, posterior ligament of head of femur; *c*, anterior ligament of head, and *d*, external anterior ligament of body of femur; *g*, capsular ligament of knee-joint. On right side, *h*, line of junction of anterior cartilage of pelvic bone; *i*, fibrous tuft attached to end of cartilage; *k*, tibial band attached to apex of tibia; *l*, distal cartilage of femur, as seen on section, dotted line marks place of junction; *m*, cartilage of head of femur, as seen on section, but cap of cartilage extended farther inwards on head; *n*, acetabular cartilage, ovoid form marked by dotted line, partly hidden by neck and head of femur; *o*, posterior cartilage of pelvic bone, limits marked by dotted lines; *q*, attachment of interpelvic ligament to cartilage of hinder end of pelvic bone; *r*, interpelvic ligament; *s*, *s*, crus penis, showing its ovoid enlargement on this aspect; *u*, corpus cavernosum after union of right and left crus; *v*, corpus spongiosum urethræ; *w*, bulb of corpus spongiosum, its hinder end concealing part of interpelvic ligament; *x*, *x*, attachment of white fibrous septum of compressor muscles along middle line of bulb and corpus spongiosum; *y*, *y*, attachment of horse-shoe septum between the compressor muscles, across crura and bulb; *z*, part of horse-shoe septum entire, showing its depth and tapering to horse-shoe raphé on surface.

Fig. 12. Upper view of same; *h*, *o*, lines of junction of anterior and posterior cartilages of this half-grown pelvic bone; *n*, part of acetabular cartilage covering narrow part of pelvic bone on this aspect; *r*, *r*, interpelvic ligament fully seen, and, continuous with it, the triangular ligament between the crura; ×, urethra, surrounded by circular and longitudinal striped muscular layers; in space between urethra and triangular ligament, are seen, on left side, three large arteries in section; *s*, crus penis, without the ovoid enlargement on this aspect; a number of arterial perforations are shown on left crus; *u*, corpus cavernosum.

Figs. 13 and 14. From same Whale as figs. 11 and 12, showing under, fig. 13, and upper, fig. 14, view of the muscles connected with same parts; and, fig. 15, a transverse section of the penis and its muscular surrounding.

Fig. 13. *a*, posterior or caudal muscular mass, attached to pelvic bone; *b*, anterior or trunk muscular mass, attached to pelvic bone, femur, and tibia; *c*, strap-like tendon, continued from flat tendinous layer concealed by the trunk mass, seen sending curved process inwards to body of femur, and another process back over head of femur to pelvic bone and caudal mass; *d*, inferior longitudinal capsular muscle, its tendon

covering head of femur, and thin continuation inwards as far as great posterior ligament, *e*; to inside of latter, the thin posterior muscle, *g*, of body of femur and tibia, seen coming from great posterior ligament, pelvic bone, and horse-shoe raphé; *h*, rectum, its circular and longitudinal muscular layers seen in transverse section; *i*, remains of anterior part of levator ani muscle; *k*, *k*, right and left rope-like muscle, retractor penis, of pale unstriped muscular fibre; *l*, *l*, great anterior compressor muscle, united to its fellow at median raphé; dotted line at its posterior origin shows how far it arises over pelvic bone; *m*, posterior compressor muscle, united to fellow by median raphé; the white semi-circular line between the two compressor muscles is the horse-shoe raphé, the superficial edge of the concealed horse-shoe septum.

Fig. 14. Upper view of same; the same letters refer to the same parts as in fig. 13; the flat tendinous layer, *c*, above the trunk muscular mass, is fully seen. Additional references are, *n*, superior longitudinal capsular muscle, seen binding head of femur on this aspect; *o* part of surface of corpus cavernosum not covered by great compressor muscle; *r*, *r*, triangular ligament, pierced by the urethra, ×; *s*. *s*, neck of bladder, surrounding urethra; several large arteries are seen in section, piercing interpelvic ligament in front of neck of bladder; *k*, rope-like muscle, seen arising mainly from neck of bladder, partly from walls of rectum, and turning forwards round hinder edge of interpelvic ligament; *t*, fibrous bundles suspending rectum; *u*, oval space between origins of the suspensory bundle.

Fig. 15. Transverse section of penis and surrounding great compressor muscle, at about 3 inches in front of horse-shoe septum. Shows the laterally compressed form of the penis within this muscle. The white part is dense fibrous tissue, enclosing, above, *v*, the erectile tissue of the fused corpora cavernosa, with a large dorsal vein or veins; and below, the erectile tissue of the corpus spongiosum, containing, near its upper part, the very distensible urethra. Above the corpus cavernosum is seen the shallow median septum between it and the dorsal raphé; below, is seen the deeper median septum, also of white fibrous tissue, between the corpus spongiosum and the inferior raphé. The section shows the great thickness of the enclosing muscle, at the sides and below. The form of the erectile medulla of the corpus cavernosum, and of the corpus spongiosum, is seen in figs. 13 and 14.

Figs. 16, 17, and 18. From Whale No. III.; female, 48 feet long; three views of under aspect, left side; showing, fig. 16, the ligaments; fig. 17, the deep muscles; fig. 18, the superficial muscles attached to the pelvic bone, femur and tibia.

Fig. 16. *a*, great posterior ligament of body of the femur (in this fig. this ligament is diagrammatic, it was naturally much more expanded, and the trochanter was, accordingly, scarcely present); *b*, posterior ligament of head of femur; *c*, anterior ligament of head; *d*, external anterior ligament of body; *e*, internal anterior ligament of body of femur; *m*, cartilage of head of femur; dotted line farther in shows outer edge of acetabular cartilage; *h*, anterior cartilage of pelvic bone; *r*, *r*, interpelvic ligament (female); *s*, antero-posterior section of this great ligament, showing its breadth and thickness; *u*, *u*, curved line on ligament, in front of which it is excavated for attachment of great genital muscular mass; dotted line shows line of inner edge of pelvic bone, concealed by this attachment of interpelvic ligament.

Fig. 17. *a*, caudal muscular mass; *c*, the flat expanded muscle and tendon seen on removing great anterior muscular mass; to right hand, a smaller stratum is seen decussating with the greater, and going to strap-like tendon; b^2, deep part of the pyramidal portion of anterior muscular mass, inserted on pelvic bone; *d*, inferior longitudinal capsular muscle; the tendinous capsule of the head of the femur, formed here by this muscle and the strap-like tendon, is seen slit open and hooked outwards, exposing the head, large in this individual, separated from the capsule by loose connective tissue; the thin inward expansion of this posterior capsular muscle is seen, in this individual, extending over great posterior ligament, *e*, and passing to nearly whole length of femur; *h*, abductor muscle of femur; h^1, external adductor muscle; h^2, internal adductor muscle; *i*, capsular ligament of knee-joint; *k*, tibial band; *l*, *l*, great genital muscular mass; *r*, interpelvic ligament.

Fig. 18. *a*, caudal muscular mass; *b*, anterior muscular mass, external and greater portion; b^1, superficial parts of pyramidal portion of anterior muscular mass, seen coming from a rounded tendon and inserted on femur and tibia; *c*, strap-like tendon, seen also in figs. 13, 14, and 17; *g*, *g*. posterior aponeurosis of femur and tibia, partly muscular in fig. 13, concealing great genital muscular mass; stronger strap-like portion of it, seen passing to tibia; *h*, aponeurosis attached to inner border of tibia; *i*, capsular ligament of knee; *k*, *k*, tibial band; *m*, perineal muscular bundles arising from interpelvic ligament; *n*, *n*, bundles of flat superficial perineal muscle, partly splitting, partly arising from, the tibial band; *o*, most anterior of the superficial perineal muscular bundles, arising entirely from the tibial band. Dotted lines in this figure show position of the beak of pelvic bone and of encapsuled head of femur.